

C&EN

JANUARY 24, 1994

CHEMICAL INDUSTRY R&D SPENDING TO DECLINE SLIGHTLY IN 1994 PAGE 15

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NEWS OF THE WEEK

■ Refinements to EPA's conservative method for estimating health risks posed by pollutants are recommended in report by the National Research Council. **Page 6**

■ Solar device using thin film amorphous silicon developed in joint government-industry project could lead to solar energy generation at half the current cost. **Page 7**

■ The earthquake in Southern California, despite its severity, did little damage to most universities and other research institutions in the Los Angeles area. **Page 8**

■ ACS, other U.S. scientific societies are protesting Russian plans to conduct a closed trial of chemist Vil Mirzayanov for allegedly divulging state secrets about Russian chemical weapons work. **Page 8**

■ Eli Lilly will concentrate on its core pharmaceuticals operation and divest nine medical device and diagnostics businesses accounting for about 19% of its sales. **Page 9**

COVER: Industrial-grade washing machines in hotel laundry. Photo courtesy of PQ Corp.

BUSINESS

Major chemical firms will spend slightly less on R&D this year and are reexamining their approach to research expenditures and management, largely because of slow economic growth. **Page 15**

GOVERNMENT

EPA is planning to integrate environmental equity into all of its policies in recognition that some minority and poor communities have been overly burdened by toxic pollution. **Page 22**

SCIENCE/TECHNOLOGY

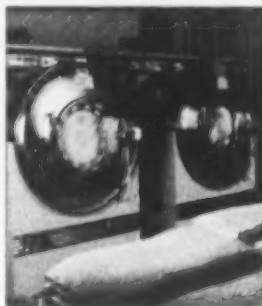
NSF's industry-university cooperative research centers program, which develops and transfers industrially relevant technologies from the university into practice, marks 20th birthday. **Page 25**

Failure of the Mars Observer spacecraft last August was due to a highly energetic chemical reaction that ruptured propulsion system tubing, concludes an independent investigative board. **Page 30**

MEETINGS

Program for the Division of Polymeric Materials: Science & Engineering conference on polymer blends and alloys features 20 presentations in five sessions. **Page 67**

PRODUCT REPORT



Soap and detergent manufacturers rely increasingly on suppliers to keep up with reformulations, motivated by consumers who want products that are more economical and have increased cleaning power as well as reduced environmental effects. **Page 34**

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LETTERS

Industry-PTS communication

I am writing you about Lois Ember's interesting article, "Chemical Industry Offers Its Expertise for Implementing Chemical Arms Pact" (C&EN, Nov. 1, 1993, page 21).

In that article, Ember highlights Sylwin Gizowski's recommendation about the importance of "establishing direct and informal contact between industry associations and the Provisional Technical Secretariat (PTS)." In that regard, it would perhaps be useful to make some comments.

Since the second quarter of 1993, PTS has started establishing contacts with chemical industries to facilitate the implementation of the Chemical Weapons Convention (CWC) and to foster industry interest on all issues related to the convention. For that purpose, PTS has developed procedures for exchanging information with specific United Nations organizations, as well as with a number of industry associations, when industry-related CWC subjects are raised.

Other procedures have also been explored and introduced. For example, a seminar on national trial inspections was held in The Hague in early October 1993; PTS staff members have participated in regional industry events; and the Preparatory Commission's expert groups have met with industry representatives. The first meeting with the industry representatives was fully reported on in Ember's article. PTS is studying the possibility of organizing additional meetings with industry representatives in 1994.

On the other hand, the industries of each country should discuss their CWC-related concerns with their respective governments. Such discussions would enable their governmental representatives in the Preparatory Commission to reflect the industry's views and act as liaison between PTS and their national chemical industries as effectively as possible.

Moreover, PTS is also acting to develop

and intensify its contacts with industry. In this regard, the industry relations branch of the External Relations Division has the responsibility for establishing contact with chemical industry associations and companies and providing updated information and advice on any concerns that may arise out of the implementation of the convention. Chemical industries can always get in touch with this branch to communicate their views and concerns or to request additional information.

Raul Carlos Fernandez
Head, Industry Relations Branch
Preparatory Commission for the Prohibition
of Chemical Weapons
Provisional Technical Secretariat
The Hague

Intellectual property issues

Ann Thayer's article on Dow Plastics (C&EN, Jan. 3, page 15) concludes with an unfortunate bit of misinformation. Thayer refers to a U.S. patent issued on Dec. 21, 1993, and states that Dow "was awarded a similar patent from the World Patent Office in April." The World Intellectual Property Organization (WIPO, there is no World Patent Office) did indeed publish an international patent application on this subject matter during April, but WIPO does not issue patents. Rather, it provides, under the Patent Cooperation Treaty (PCT), a means by which an individual or corporate inventor can file a single patent application, which undergoes a unified international search in any of several patent offices, after which it is sent to the patent offices of designated individual countries and regional authorities (for example, the European Patent Office) for consideration under the laws of those countries and authorities.

This mechanism can simplify patenting procedures by replacing the traditional system under which separate applications must be filed in each office of interest, with a search carried out in each. But WIPO awards nothing. It merely publishes PCT applications, which may subsequently become patents in one or more jurisdictions, but which may never proceed beyond the level of published application.

Stuart M. Kaback
Cranford, N.J.

Correction

• Jan. 17, page 25. The telephone number to receive information about Operation Chemistry teacher training workshops is (202) 872-6366.

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Chemical Industry R&D Spending To Fall Slightly in 1994

■ **Economic pressures are causing major chemical companies to rethink strategies for research spending, management**

Ann M. Thayer,
C&EN Northeast News Bureau

Research and development, like so many other parts of industry, is experiencing the effects of slow economic growth. Downsizing, shifting focuses, and reexamined management approaches are all part of the R&D picture today.

R&D spending by 24 major chemical producers is estimated to fall an average of 1.4% in 1994, based on data recently collected by C&EN. This decrease is in contrast to an increase forecast by a major chemical industry trade group, but in line with more conservative views held by industry analysts and a survey of company R&D representatives. Cost containment measures, competitive pressures, and the lingering effects of the recession are leading companies to rethink not just how much, but also how, money is being spent on R&D.

The forecast decrease in spending in C&EN's survey for 1994 follows a year in which R&D spending slipped nearly 2%, despite more optimistic expectations a year ago. Total spending for the group of 24 companies surveyed is expected to reach \$4.68 billion in 1994, down from \$4.74 billion in 1993. In the past several years, the largest increases in R&D spending occurred between 1988 and 1990, when spending grew 8 to 10% per year. However, with a recession taking hold, R&D spending fell in 1991 and has not really recovered.

For 1993, a comparison of planned spending and actual spending shows that companies surveyed by C&EN ended up cutting back throughout the year.

Planned 1993 spending for the 14 companies that provided estimates totaled \$3.75 billion. Actual spending reached only \$3.65 billion for the year, a decrease of nearly 3%.

Industrial R&D spending varies significantly among different sectors, and the chemical industry falls somewhere in the middle. More mature industries—such as basic metals and chemicals—don't spend a great deal on R&D in the first place, explains Jules J. Duga, senior R&D policy analyst and lead author of Columbus, Ohio-based Battelle's annual R&D spending forecast, which is expected to come out next month. At the extremes, the petroleum industry spends only about 1% of sales on R&D, whereas the more high-tech areas of pharmaceuticals, telecommunications, transportation, and electronics spend as much as 15% of sales.

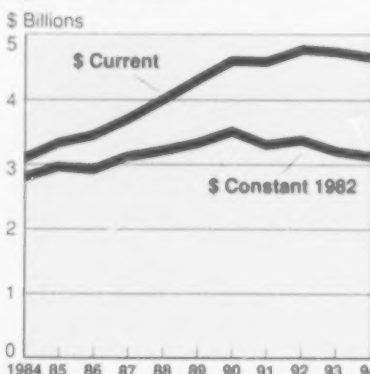
Battelle forecasts total U.S. R&D spending for 1994 to reach \$165 billion, a 2.4% increase over estimates for 1993. Industry will account for nearly 52% of this spending in 1994, rising only 1.6% to \$85 billion. However, about 70%, or \$115 billion, of total R&D dollars will be spent on re-

search conducted by industry. About 72% of these funds will come from industry itself, with the remaining 28% from the federal government. Industry also will spend about \$2.4 billion on R&D at universities and nonprofit organizations, a 6.2% increase over 1993.

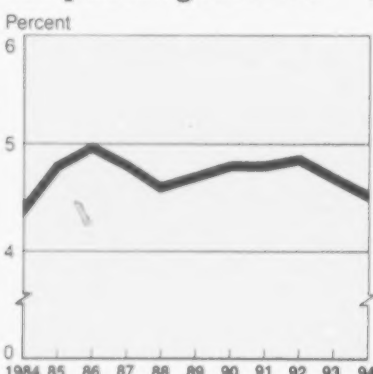
In terms of constant dollars, R&D expenditures in 1994 will remain essentially flat relative to 1993, according to Battelle. Recession and other economic pressures have been major contributors to keeping spending down. "The first expenses to get cut are those that are viewed as nonrevenue producing, and, unfortunately, R&D is viewed by most people as being nonrevenue producing—that is, not producing revenue by the end of the next quarter," says Duga.

However, Duga predicts that R&D spending will start to pick up again around mid-decade. A slowdown in industrial profitability and growth, irrespective of what Duga calls the "paper" profit increases that are essentially the result of company reorganizations, has contributed to a Slinky spring toy effect on R&D spending. After recovery begins within the industry and profitability starts going

R&D spending will decline again in 1994 ...



... and will drop slightly as a percentage of sales



Note: For 24 chemical companies listed on page 16.

Sources: C&EN surveys and estimates; Battelle; National Science Foundation

Chemical companies surveyed show diverse R&D spending plans for 1994

\$ Millions	Planned 1994	Actual 1993	Planned 1993	1992	1991	1990	1989	1988	Change from prior year		R&D spending as % sales	
									1994	1993	1993	1992
Air Products & Chemicals^a	\$ 94	\$ 92	\$ 93	\$ 85	\$ 80	\$ 72	\$ 71	\$ 72	2.2%	8.2%	2.8%	2.6%
Arco Chemical	75	72	65	67	64	59	52	39	4.2	7.5	2.2	2.2
Crompton & Knowles	10	10	na	10	10	8	8	6	0.0	0.0	1.8	1.9
Dow Chemical	1,200	1,270	1,320	1,289	1,159	1,136	873	772	-5.5	-1.5	6.6	6.8
DuPont^b	1,100	1,100	1,198	1,217	1,224	1,381	1,327	1,255	0	-9.6	5.0	5.6
Eastman Chemical^{c,d}	174	166	na	162	154	148	na	na	4.8	2.5	4.3	4.3
Ethyl^e	130	124	80	73	69	65	61	59	4.8	69.9	4.1	2.5
First Mississippi^f	6	5	na	4	4	4	4	4	20.0	25.0	0.9	0.8
FMC	165	147	150	145	135	58	150	144	12.2	1.4	3.6	3.6
H. B. Fuller^{g,h}	22	21	na	20	17	16	16	14	4.5	4.3	2.2	2.1
Great Lakes Chemical^d	48	46	na	47	39	29	31	28	4.5	-3.1	3.0	3.1
Hercules	67	70	70	70	86	92	79	74	-4.3	0	2.4	2.4
Imceraⁱ	100	95	na	91	81	76	65	65	5.3	4.4	5.5	5.3
Loctite^h	27	27	na	26	22	19	17	15	0	3.8	4.4	4.3
Lubrizolⁱ	88	88	88	91	80	74	70	65	0	-3.3	5.6	5.9
Monsanto^j	580	620	na	651	610	595	581	556	-6.5	-4.8	7.9	8.4
Morton International^j	73	69	67	61	59	48	38	35	5.8	13.1	3.2	2.8
Nalco Chemical	54	51	na	48	47	45	41	37	5.9	6.3	3.6	3.5
Olin	40	40	35	39	41	66	66	58	0	2.6	1.7	1.6
Petrolite^k	14	14	13	12	11	12	12	12	0	16.7	4.3	3.8
PPG Industries	221	219	215	203	220	236	249	239	0.9	7.9	3.7	3.5
Praxair^l	53	54	na	60	58	58	54	49	-1.9	-10.0	2.0	2.3
Rohm and Haas	207	205	210	199	183	178	175	156	1.0	3.0	6.6	6.5
Union Carbide^m	129	140	150	155	157	157	143	126	-7.9	-9.7	2.8	3.2
TOTAL	\$4,676	\$4,744	\$3,754	\$4,825	\$4,610	\$4,732	\$4,183	\$3,878			4.5%	4.7%
ANNUAL CHANGEⁿ	-1.4%	-1.7%		4.7%	-2.6%	9.6%	7.9%	7.6%				

^a Fiscal year ends Sept. 30. ^b All figures exclude Conoco. Prior to 1991, figures include pharmaceutical research now part of DuPont Merck Pharmaceutical Co. ^c Spin off from Eastman Kodak on Jan. 1, 1994. ^d Figures for 1993 and 1994 based on company data and C&EN estimates. ^e Data refer to combined chemicals and to insurance and lubricant additives operations that are to be divided into separate companies. Prior to 1989, data include Tredagar Industries, which was spun off in July 1989. ^f Fiscal year ends June 30. ^g Fiscal year ends Nov. 30. ^h Prior to 1990, fiscal year ended June 30. ⁱ Data for 1993 and 1994 exclude Agrigenetics division, which formed the basis of a joint venture with Mycogen in December 1992. ^j Figures for 1993 and 1994 are estimates. Data from 1987 through 1992 stated to exclude Fisher Controls, which was sold in October 1992. ^k Fiscal year ends Oct. 31. ^l All figures restated by company to conform to industrial gases industry definition of R&D. Spun off from Union Carbide on June 30, 1992. ^m Figure for 1994 does not include R&D spending in organosilicons business sold in 1993. All figures reflect spin-off of Praxair on June 30, 1992. ⁿ For those companies reporting. na = not available.

up, it takes time to restart the R&D engine, he says. "So it's like a Slinky toy—you pull on the front end and the back end doesn't move for a while."

Industrial Research Institute's Annual R&D Trends Forecast, released in November, predicts a similarly pessimistic scenario for 1994, seeing the year as a continuation of the recession for industrial R&D in the U.S. Among a subgroup of 45 companies in chemicals and plastics, the Washington, D.C.-based IRI found that R&D budgets are expected to rise only 0.42% in 1994. And, as a percent of sales, R&D spending will remain at its 1993 level of 3.4% in 1994, although a second IRI study reports this figure as about 5%.

In a survey of its member companies, the Chemical Manufacturers Association (CMA) found that companies are optimis-

tic about the near future, despite lackluster performance in 1993. With modest sales growth of about 5% expected in 1994, CMA says R&D spending is expected to rise only about 4% over 1993 to about \$15 billion. Based on 91 companies reporting, 60% expect to increase spending, 28% expect to keep spending flat, and 12% anticipate declines. The discrepancies among C&EN's, Battelle's, and CMA's figures may be due not only to different survey sizes, but also to the fact that CMA's predictions were made in November 1993, before many companies had finalized their 1994 spending plans.

Of the 24 companies surveyed by C&EN, 10 projected increases in R&D spending in 1994 above the 2% inflation rate supplied by the National Science Foundation (NSF). Many of the companies predicting spending cuts in 1994—

including Union Carbide and big spenders such as Dow Chemical and Monsanto—also cut spending in 1993. Decreases are planned by five companies, with the rest predicting spending to remain flat in terms of real dollars.

Included in C&EN's survey group are FMC and PPG Industries, whose businesses are somewhat more diversified than others in the chemicals area. Without these two companies, spending for the remaining 22 companies fell 2% in 1993 and is expected to fall another 2% in 1994. First Mississippi, from a very small base level, and FMC plan double-digit increases for 1994, whereas most others are keeping increases between 4 and 6%. Union Carbide's nearly 8% decrease, the largest reported decline, is due primarily to the sale of its organosilicons business in 1993.

Increases in pharmaceutical R&D spending slip to single digits

R&D spending by pharmaceutical companies seems to have entered a new era in 1993 and 1994—one of only single-digit increases. In surveying major pharmaceutical companies, C&EN found that 1993 R&D spending at six companies rose only 7% from 1992. The relatively small increase, half that of previous years, suggests that health care reform, as well as economic and pricing pressures, are affecting the industry.

C&EN's smaller sampling of companies compares well with the results of a larger survey recently reported by the Pharmaceutical Manufacturers Association (PMA) (C&EN, Jan. 17, page 7). PMA members encompass more than 100 research-based companies, including 40 biotechnology companies, which account for 90% of pharmaceutical sales within the U.S. PMA's research-based member companies reported an increase of about 10% in R&D spending in 1993. This

increase, says PMA, is significantly less than the average annual increase of more than 16% from 1980 through 1992. Total R&D investments by the PMA-surveyed companies reached \$12.6 billion in 1993.

For 1994, the drug industry R&D spending picture does not look much brighter. Pharmaceutical companies contacted by C&EN were extremely reticent about predicting their R&D spending levels for 1994. However, PMA found that 1994 R&D spending is anticipated to rise 9.5%, to \$13.8 billion. According to PMA, this increase is the first single-digit increase since 1977.

However, contrary to holding down their increases in total dollars invested, companies will spend a higher percentage of their sales on R&D. In 1994, PMA says that companies intend to invest 18.8% of sales in R&D as compared with 18.3% in 1993. In a November 1993 survey of its member

companies, PMA found that R&D spending has grown "substantially faster than sales for more than two decades"—R&D spending grew at a compounded annual rate of 14% from 1970 to 1993, whereas sales grew at a rate of about 12%.

C&EN's survey of six companies found R&D spending as a percentage of estimated sales reached about 13% in 1993, up slightly from 1992. Without Warner-Lambert, which reinvests a much lower percentage than other companies, R&D spending as a percentage of sales would be about 14%. Similarly, from its survey of eight pharmaceutical companies, Industrial Research Institute, Washington, D.C., reports reinvestment at 12%. Other than differences in survey size, PMA's data may be skewed by the inclusion of its biotechnology company members, since even the more established companies of these are known to spend 50% or more of their sales on R&D.

\$ Millions	R&D spending				R&D as % of sales			
	1993	1992	1991	1990	1993 ^a	1992	1991	1990
Eli Lilly	\$ 960	\$ 925	\$ 767	\$ 703	15.3%	15.0%	13.5%	13.5%
Merck	1,200	1,112	988	854	12.2	11.5	11.5	11.1
Pfizer	920 ^b	863	757	640	12.4	11.8	10.9	10.0
Schering Plough	580	522	426	380	14.1	12.9	11.8	11.4
Upjohn	633 ^b	549	491	427	17.1	15.1	14.4	14.1
Warner-Lambert	465	474	423	379	8.2	8.5	8.4	8.1
TOTAL	\$4,758	\$4,445	\$3,852	\$3,383	12.9%	12.2%	11.5%	11.2%
CHANGE FROM PRIOR YEAR	7%	15%	14%	15%				

^a Based on estimated sales for 1993. ^b Based on company data and C&EN estimates.

The most consistent result among different surveys is that chemical companies seem determined to keep constant their R&D spending as a percent of total company sales. C&EN's average of 4.5% over the past decade agrees with findings by CMA and IRI. But, to keep this ratio constant, a decrease in R&D spending means a concurrent decrease in sales. In 1993, estimated overall R&D spending as a percent of sales for the 24 companies reported here will be 4.5%, down from 4.7% in 1992. An 11-year low of 4.3% occurred in 1984.

R&D spending also is gaining as a larger share of future-oriented spending. Based on 14 companies that appear in both C&EN's R&D and capital spending surveys, R&D spending as a percentage

of combined research and capital expenditures will reach 39% in 1994, up from 36% three years ago. [Air Products, Arco Chemical, DuPont, Eastman Chemical, First Mississippi, FMC, H. B. Fuller, Great Lakes Chemical, Imcera, and Locite are excluded because they do not appear in the 1994 capital spending survey (C&EN, Dec. 20, 1993, page 11)]. However, the gain on a percentage basis belies an overall spending decrease and that most capital expenditures are going toward process improvements and expansions as a means to curb costs, rather than into new investment.

R&D employment is being hurt somewhat by changes in spending and company reorganizations. Large employers such as Dow Chemical, DuPont, and Monsan-

to have been cutting back R&D staff. However, all three companies now expect the cutbacks to level off. But IRI found in its surveys that only 5% of companies expect to increase hiring of new graduates, while 40% expect to decrease hiring, a downward trend that has continued for the past six years. Overall, R&D professional staffing levels at 90% of the companies are to remain unchanged or to drop from 1993 levels, according to IRI.

Not only is the amount of money companies are investing changing, but also the way in which it is being spent. Duga sees six major trends affecting industrial R&D: a short-term leveling of real R&D expenditures; an increase in contracting to other domestic performers such as universities and independent

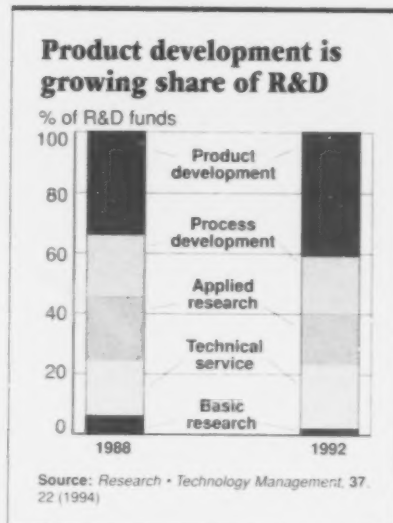
labs; the offshore acquisition of technological assets that are cheaper or more closely aligned with local market needs; the expansion or development of ad hoc alliances with other companies and with research facilities; a greater interaction with the federal labs; and, within individual industries, a more aggressive search, often via databases and/or a corporate technology "gatekeeper," to identify and acquire both finished and in-process technological assets.

R&D management executives at Monsanto, Dow Chemical, and DuPont confirm that many of these trends are happening. They also describe an increased interest in collaborative, precompetitive research programs with other companies. Such alliances can serve as a means to expand companies' technology bases more economically. In the future, managers and analysts alike predict that companies will be coming together to work in "noncompetitive" areas, such as the environment, to develop technologies that benefit an entire industry.

Many industries—the chemical and petroleum industries are good examples—are cutting back on a lot of the basic research performed in-house, says Duga. "The research structure of major industries has changed in the sense that research is much more driven by operating unit needs as opposed to corporate-driven research that is much longer term [in outlook]." However, Duga believes this cutback on in-house expenditures, particularly in basic research, may be offset by a greater degree of research being performed on a contract basis. Others, such as IRI, expect significant decreases in grants for university research.

The idea that research is being driven more by company business unit needs is not a new one. Chemical company R&D managers tell C&EN that their companies have been exploring and strengthening the connections between business and R&D for some time. Selecting, aligning, or integrating technology with business planning and strategy has become an ideology of industrial R&D managers, in part helping them to justify the continued relevance.

Company managers also talk about being more selective in the use of resources and consolidating or leveraging certain research functions—analytical sciences, pilot-scale research, information sciences—to eliminate redundancies and make the R&D process more efficient and cost effective. There also is an increased emphasis



on "shorter cycle times"; that is, bringing R&D results to the business units or marketplace more quickly. However, these changes do not mean that R&D serves only as a supporting function to business, but in many cases is expected to expand business areas through new product and process innovations.

For example, Dow has been reducing R&D or technical support for some of its mature businesses while giving more emphasis to breakthrough technologies that significantly enhance existing businesses or create new businesses. The company also has made some organizational changes to more directly align R&D with its businesses, explains Fred P. Corson, Dow's vice president for R&D. The company now has global R&D vice presidents for each of its major business groups. These individuals report both to Corson for the R&D function and to the business group vice president.

Three components of Dow's R&D—central research, health and environmental sciences research, and core technical capabilities that support the entire company such as analytical science, materials science, and engineering science—still are organized and funded on a corporate basis. Dow also has a global ventures business unit, formed about a year ago, that works with R&D and the business groups to find or create new business opportunities through technology innovation, acquisition, development, and commercialization.

Companies still are retaining research with a long-term focus, but may now also tie this to business interests. Monsanto's biotechnology R&D effort, once a major,

free-standing part of corporate R&D, has been transferred to the company's pharmaceutical and agricultural units, explains Philip Needleman, senior vice president and chief scientist at Monsanto. About half the number of scientists remain in corporate R&D, and are those who focus primarily on synthetic chemistry of broad interest to the entire company.

The effect has been to make a large portion of Monsanto's corporate R&D budget—more than \$60 million—"disappear" into other areas by specifically aligning the research with operating businesses. Needleman says the support and nature of the company's biotechnology research hasn't changed at all, but that the move makes sense because products are now coming to fruition.

The trend of aligning research and business has become so prevalent that IRI, with the help of the Center for Innovation Management Studies at Lehigh University in Bethlehem, Pa., conducted its first survey to assess R&D spending and performance on the level of individual company business segments and corporate labs. Based on data for 1992, the survey looked to gain quantitative figures on the sources and allocation of R&D funds as well as on the outcome or return a company gets from R&D.

Contrary to "common wisdom," IRI found that just because an R&D organization depends upon the business units for funding doesn't mean that it will receive less support than if it received corporate funding. In the chemicals area, about 23% of R&D funding comes from corporate sources and the rest from business units. In terms of allocating funds, the chemical industry comes very close to averages: less than 5% goes to basic research, nearly 20% goes to applied research, about 20% goes to technical service, and the rest goes to product and process development.

Based on data going back to 1988, the study also found that a predicted shift in funding from exploratory research to product and process development has occurred. What was most difficult to measure, concludes IRI, is outcome or return from R&D. The survey identified "measuring and improving R&D productivity/effectiveness" as the largest problem research directors face. At the same time, this information is becoming increasingly desirable, even crucial, to have as firms report an increased scrutiny by top management who are looking to understand the impact of technology on business and the return from R&D expenditures. □

SOAPS & DETERGENTS

Industry relies increasingly on suppliers to keep up with fast-paced reformulations

Susan J. Ainsworth,
C&EN Houston

Judging from the meager rate at which it has been growing, the huge U.S. soap and detergent business appears to be mature. In 1993, for instance, industry shipments of soap and detergent products rose only 2% from the previous year to \$14.9 billion, according to the Department of Commerce's U.S. Industrial Outlook report on cleaning preparations and cosmetics released this month. And in constant dollars, industry shipments are forecast to increase only 2% in 1994 and only slightly more than 2% annually for the next five years, the Commerce report adds.

However, this big, sluggish industry is far from stagnant. Motivated by concerns about the environment and getting more for its dollar in the midst of recessionary pressures, the public continues to put pressure on the soap and detergent market to keep evolving. Because household laundry products make up the largest segment of the detergent chemicals market, the consumer's vote—cast in terms of spending dollars—counts.

Consumers are still pushing hard for minimal packaging for their cleaning products. They want assurance that the

products they buy contain "natural" ingredients that will not be harmful or irritating during use. The public demands that the cradle-to-grave life cycle of the products be environmentally sound as well. At the same time, consumers have come to expect more value, which they define as better product benefits at little or no extra cost. They want products that combine more than one cleaning function in a single product.

As a result, soap and detergent manufacturers have had to rethink their products from the inside out. The past several years have probably represented the "most dynamic period of change that the American detergent market has seen since the introduction of synthetic detergents in 1947," observes J. Keith Grime, associate director for product development at Procter & Gamble, Cincinnati. For example, just since 1990, the industry has witnessed the virtual conversion of the North American laundry detergent market to compact powders and, in 1993, the emergence of new liq-

uid concentrate products—both of which require less product and packaging per wash load when compared with traditional detergent products.

"All of us who have been involved have had a fascinating and exciting ride on the R&D roller coaster as we provided technology that fueled the rapid-paced and highly competitive marketplace developments," Grime adds. "There has never been a dull moment."

The reformulation trend is creating many challenges for companies that produce and supply soap and detergent ingredients such as surfactants, builders, bleaching agents, and enzymes. Suppliers continue to have to "focus on the global market needs of the detergent industry and to serve those needs with technological development, technical support, and low-cost supply of ingredients," says Lewis G. Furman, marketing director for FMC's phosphorus chemicals division, Philadelphia.

Adds Lois Marquardt, business manager for sodium silicates at Occidental Chemical, Dallas, "Our business is oriented to respond to the changing requirements of the soap and detergent industry and we are continually making special grades to meet those needs."

Suppliers are increasingly being asked by their soap and detergent customers to partner with them to help develop crucial reformulation technology. They realize that "there's a much better chance for success at developing a new ingredient when they focus their efforts, picking one or two suppliers and really working with them rather than asking 10 suppliers to make bids," says David LeBlanc, surfactants business director for Hoechst Celanese, Charlotte, N.C.

"Our customers have to pick suppliers who have the capability to manipulate processes and molecules to give them the properties they need," says William Huisking, vice president of the performance chemicals division of Lonza, Fair Lawn, N.J., a company that plows in excess of 15% of its sales back into R&D for what it deems its "strategic products."

"Partnering—getting together to talk about our customers' formulation needs—only makes sense, because we are the experts on zeolites and silicates and they are the experts on laundry detergents," says Thomas H. Gudowicz, business manager for zeolites at PQ Corp., Valley Forge, Pa. "Our customers are really opening up and realizing that they have to use suppliers as an extension of their R&D, manufacturing, and logistics systems."

Soap and detergent producers use partnering relationships to help them keep up with the many demands of a complex marketplace. Simply giving presentations or providing technical literature to customers on suppliers' products isn't good enough anymore, notes Jeannene Ackerman, vice president for laundry products at Witco, New York City. In addition to wanting more hands-on technical help, "customers are also asking suppliers to determine whether patents may be an impediment to a specific formulation, or if a premanufacturing notice is required before a new ingredient can be produced," says Lawrence Moss, Witco's vice-president for personal care, household, industrial, and institutional surfactants.

"Soap and detergent customer demands and needs have focused more on quality in the past few years," adds Marquardt. "[Manufacturers] are establishing and implementing programs to evaluate production processes and procedures and to measure raw material quality consistency. The goal is to systematically select suppliers on a quality

basis. All of our plants have a working in-house statistical process control/statistical quality control program that enables us to respond to customer demands. We have the capability to provide customers with specific data that measure all phases of our process and finished product."

Partnering also takes some of the cost burden off of soap and detergent manufacturers, allowing them to spread some of the cost to suppliers. "Customers don't have unlimited resources. They have to optimize what they have and one way to do that is to rely more upon suppliers," says Lonza's Huisking.

This reliance is increasingly important to soap and detergent manufacturers as they find it tougher to pass on development costs in the prices of their consumer products. Although newer detergent products offer consumers additional benefits (such as being more environmentally benign), they don't necessarily allow manufacturers to sell those benefits at a premium over the products they replace.

Profiting on new products is especially tough as the lingering recession

continues to send consumers gravitating toward "value" brands rather than premium labels. To compete with such brands and with products sold at discount stores, which have the buying leverage to discount even premium products, soap and detergent manufacturers have had to slash prices on name brand products sold in all outlets.

"Manufacturers' claims that they have had to reduce prices for finished detergent products are true," says John Parker, business manager for persalts



Solvay Interax photo



PQ Corp. photo

Suppliers' technicians analyze detergent ingredients, checking thermal stability of persalt (above) and viewing zeolite crystals with a scanning electron microscope.

The anatomy of a laundry detergent

All laundry detergents perform the same basic functions, but there's broad diversity among detergent formulas. Although they may contain the same basic components such as surfactants or builders, for example, each formulation may vary in the type and amount of those components.

Surfactants

The surfactant or surface-active agent improves the wetting ability of water; loosens and removes soil with the aid of wash action; and emulsifies, solubilizes, or suspends soils in the wash solution.

Surfactants are organic compounds consisting of two parts: a water-attracting (hydrophilic) portion and a water-resistant (hydrophobic) portion. The hydrophobic ends attach themselves to the soil particles or to the fabrics being washed while the hydrophilic ends are attracted to the water. The surfactant molecules sur-

round the soil particles, break them up, force them away from the surface of the fabric, then suspend the soil particles in the wash water.

Detergents may contain more than one kind of surfactant. These surfactants differ in their ability to remove certain types of soil, in their effectiveness on different fabrics, and in their response to water hardness. Surfactants are classified by their ionic (electrical charge) properties in the water. Anionic, nonionic, and cationic are the major surfactant types used in laundry products.

Builders

The builder in a detergent formulation enhances or "builds" the cleaning efficiency of the surfactant by inactivating water hardness minerals. Builders soften water by sequestration, precipitation, or ion exchange. Most builders provide a desirable level of alkalinity, which aids in cleaning, and

disperse and suspend soils to prevent their redeposition.

Antiredeposition agents

Antiredeposition agents may be made from complex cellulosic materials such as carboxymethyl cellulose or synthetic materials such as polyethylene glycol and polyacrylates. They aid in preventing loosened soil from redepositing onto cleaned fabrics.

Corrosion inhibitors

Corrosion inhibitors, usually sodium silicate, help protect washer parts from corrosion.

Fluorescent whitening agents

Fluorescent whitening agents or brighteners are complex organic molecules that adhere to fabrics as though they were dyes. Ultraviolet energy is absorbed, converted, and emitted as visible blue light to enhance fabric appearance and maintain whiteness or brightness.

at Solvay Interlox, Houston. For example, "The cost per wash for liquid detergents, which up to 18 months ago used to carry a significant premium, is now much more in line with the cost of using powdered detergents."

"Of course," says Hoechst Celanese's LeBlanc, "that price pressure comes back to the companies selling raw materials." Parker adds, "Lower costs in the stores mean the manufacturers must continue to seek economies wherever they can find them" and that affects Solvay Interlox's business. He adds, "The focus on supplier value continues to increase; the need for close customer contact is more vital today than ever before."

Indeed, suppliers are pinched by the additional price pressure, cost, and time required to meet their customers' growing partnering demands, but the investment eventually pays off, says Michelle Borland, market manager for detergent raw materials at Texaco Chemical, Houston. Although Texaco Chemical has had to devote more of its R&D resources to joint projects with its soap and detergent customers, "It's an additional way to start us working as a team with them and that's a good way to build a strong relationship."

For one thing, Borland continues, partnering has "allowed us to get in on

the ground floor with customers on projects." PQ's Gudowicz agrees, adding, "We seem to be getting an earlier look at what products customers want to formulate in the future. We know the specific property that they are looking for and so we have a chance to formulate new products in concert with them."

Having the inside track on what soap and detergent producers are looking for is increasingly important. As they try to position any new product developments in soap and detergent formulations, suppliers have also been fighting to keep their established ingredients on the winning side of the reformulation war. Unavoidably, some products have been and will continue to be crippled by reformulation trends that have led the industry toward replacement products.

Although total demand for detergent chemicals is slated to increase less than 3% per year through 1996, prospects for certain ingredients that are compatible with reformulation trends are much better, according to a detergent chemicals study done last year by Cleveland-based consulting firm Freedonia Group. For example, the best growth opportunities among detergent chemicals will center on nonphosphate builders such as

zeolites and high-priced, smaller volume chemicals such as enzymes, says Freedonia industry analyst Luci Young.

Likewise, Young notes that industry trends toward the development of multifunctional products and liquid detergent formulations will favor chemicals that are compatible with a wide range of other chemicals. "As the popularity of multifunctional detergents continues, both enzymes and bleaches will experience above-average growth," she says.

Concentrated detergents

Certainly no recent reformulation trend has shaken up the soap and detergent chemicals market like the massive move to concentrated laundry detergents.

Indeed, growth in the new concentrated liquid and powder formulations will boost future growth of surfactants, which are needed in greater concentrations in these products. Partly because of the proliferation of concentrated products, in 1993, industry shipments for surfactants used in soaps and detergents increased more than 3% to \$3.5 billion, or 2% in constant dollars, according to the Commerce report. Exports increased more than 3% to \$567 million, while imports increased to \$210 million, producing a positive trade balance of \$357 million, the Commerce report adds. In 1994,

Processing aids

Processing aids cover a considerable list of ingredients including sodium sulfate, water, and solvents such as alcohol or xylene sulfonate. They provide the product with the required physical properties for its intended use. Sodium sulfate, for example, helps provide crisp, free-flowing granules. Alcohols are often used in liquid products where they serve as solvents for the detergent ingredients, adjust the viscosity, and prevent product separation. Because the water content of liquids is fairly high, alcohols also protect the product under extremely cold storage conditions by lowering the freezing point.

Colorants

Colorants are added to lend individuality to the product or to dramatize a special additive that contributes to product performance. Additionally, blue colorants may provide a bluing

effect that imparts a desirable blue-white color to white fabrics.

Fragrances

Fragrances have three functions, regardless of the specific scent used. They cover the undesirable odors of the detergent itself and of the soils in the washing solution. Plus, they impart a pleasant scent to fabrics, thus reinforcing the cleaning performance. Additionally, a fragrance contributes to the character of the product. Some detergents are offered in unscented versions, appealing to consumers who prefer little or no scent on laundry. They may also appeal to people whose skin is sensitive to fragrance ingredients.

Opacifiers

Opacifiers are used in some liquid products to provide a rich, creamy, opaque appearance.

Oxygen bleach

Oxygen bleach provides the deter-

gent with an all-fabric bleaching action for stain and soil removal.

Enzymes

Enzymes aid in breaking down complex soils, especially proteins such as grass and blood, so that they can be more easily removed by other detergent ingredients.

Suds control agents

Suds suppressors inhibit sudsing or control it at a low level. Special long-chain soaps are one class of compound used to control sudsing in granular and liquid laundry detergents.

Fabric softening agents

Fabric softeners impart softness and control static electricity in fabrics. Cationic surfactants such as quaternary ammonium compounds are commonly used.

Source: Soap & Detergent Association

the value of industry shipments will increase 2% in real terms.

The Freedonia report on detergent chemicals has basically the same forecast. Demand for surfactants used in household and industrial and institutional detergents will increase 2.1% per year through 1996, the consulting firm predicts.

One company that will be well positioned to take advantage of growth across the board in surfactants is Huntsman Corp., which is now expected to be formed no earlier than the end of next month through the completion of Huntsman Financial Corp.'s purchase of Texaco Chemical. The company's purchase of Monsanto's linear alkylbenzene (LAB) business last month, "makes the new Huntsman Corp. a much stronger player in the detergent business, because now not only will we be a full-range nonionics supplier, we will have anionics as well," says Borland. "With two key pieces of most detergent formulations, we will have a broader product line to offer our customers. These acquisitions show a very strong commitment to the detergent business."

Nonionic surfactants

Among all surfactants, nonionics will provide the greatest opportunities because of their ease of incorporation into

liquids, better resistance to hard water ions, and advantages over anionics in cleaning synthetics, as well as moderate cost, says Freedonia's Young.

Among nonionics, the current market forecast is that demand for ethoxylated products will grow in most traditional applications, says LeBlanc. "In addition, we expect growth in the market owing to manufacturers' substituting ethoxylates for existing surfactants where ethoxylates offer superior properties." Growth rates for linear alcohol ethoxylates could go as high as 5 to 7% per year, "if some of rumored substitutions do occur," says LeBlanc.

However, one factor that limits the wholesale substitution of nonionics for other surfactants is limited production capacity, says LeBlanc. With this in mind, last month Hoechst Celanese began construction of a new ethoxylates unit at its Clear Lake, Tex., plant. When the plant starts up in fourth-quarter 1994, the facility will have capacity to produce 150 million lb per year of alcohol ethoxylates and other ethoxylated products. "This new facility will allow us to supply existing customer demands and will give us flexibility for expansions and new products," adds LeBlanc.

Nonionics have also benefitted from the reformulation trend toward concentrated

detergents. Now that most of the major producers of detergents have completed the switch over to concentrates, industry demand for synthetic-based linear alcohol ethoxylates, which go into their premium brand concentrates, has been stable this year, says Borland.

However, growth for nonyl phenol ethoxylates, which go into less expensive, private label detergents has been strong. That's because these private label manufacturers are still in the midst of formulating and launching their own copycat concentrated formulations, and sales of these less expensive brands are booming as consumers try to save money in these leaner times.

As the economy improves, Borland does not expect sales of private label brands and nonyl phenol ethoxylates to wane. "Private label formulations have become much more sophisticated and their manufacturers are able to react in the marketplace a lot faster than they used to. So it's not likely that consumers are going to run out and buy brand products again as soon as they get a little more disposable income."

Partly reflecting its faith in the future of the detergent ethoxylates market, last month Texaco Chemical brought on stream a 25 million-lb-per-year ethoxylates expansion at its Port Neches, Tex.,

facility. Also at Port Neches, this coming July, Texaco Chemical will start up a propylene oxide plant, which would make the company "the only ethoxylates producer that will be basic in both ethylene oxide and propylene oxide," says Borland.

This statement is made assuming that Huntsman exercises its two-year option to buy a 50 or 100% interest in that plant. To capitalize on this new captive raw material source, the company is launching a new line of ethylene oxide-propylene oxide products for the automatic dishwashing market.

Surfactant producers that make products from petrochemical sources continue to face growing competition from producers of fatty alcohol-based surfactants made from renewable raw materials such as palm and coconut oils and animal fats, which consumers view as more environmentally friendly. "With the green movement, the trend is toward [use of] raw materials for surfactants based on natural products," says Erik Rietkerk, head of worldwide sales and

marketing for Singapore-based Salim Oleochemicals.

But the balance between natural- and synthetic-based surfactants is "absolutely not being decided totally by consumer demand," says Borland. Soap and detergent manufacturers want the flexibility to use oleochemical- (natural-based) or petrochemical-based raw materials so that they can purchase the type that is more economical at a given time. Texaco and Vista Chemical are two companies that produce an ethoxylate that so closely resembles the natural counterpart that they can be interchanged easily in a production process.

Vista Chemical agrees that, for the most part, customers want to maintain flexibility by being able to purchase both petrochemical- and oleochemical-based surfactants, says Tom O'Brien, manager of surfactant sales at Vista Chemical, Houston. "There will always be some small segment of the market that demands natural, but for the most part, [formulators] are now using good science in choosing their surfactant raw materials."

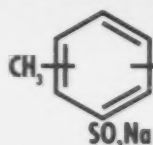
Natural fatty alcohol prices have been higher than those for their petrochemical-based counterparts over the past few years. Most notably, coconut oil prices jumped from 20 cents per lb to 30 cents per lb between early November and mid-December. So synthetic versions look a little more attractive now, even though producers of some petrochemical-based products raised their prices during the course of 1993.

"There will always be short-term disparities in pricing between oleochemical alcohol, petrochemical alcohol, ethoxylates, and LAB because there are a lot of factors that set pricing," says O'Brien. "But over the long term, these products will have price parity if they want to remain as workhorse surfactants."

Rietkerk agrees. "I think natural-based alcohols will have to move toward the pricing level of synthetics in order to be competitive, especially in North America." He also agrees with Borland, who predicts, "Over time, as more natural alcohol capacity comes on, you will see price parity between the two products."

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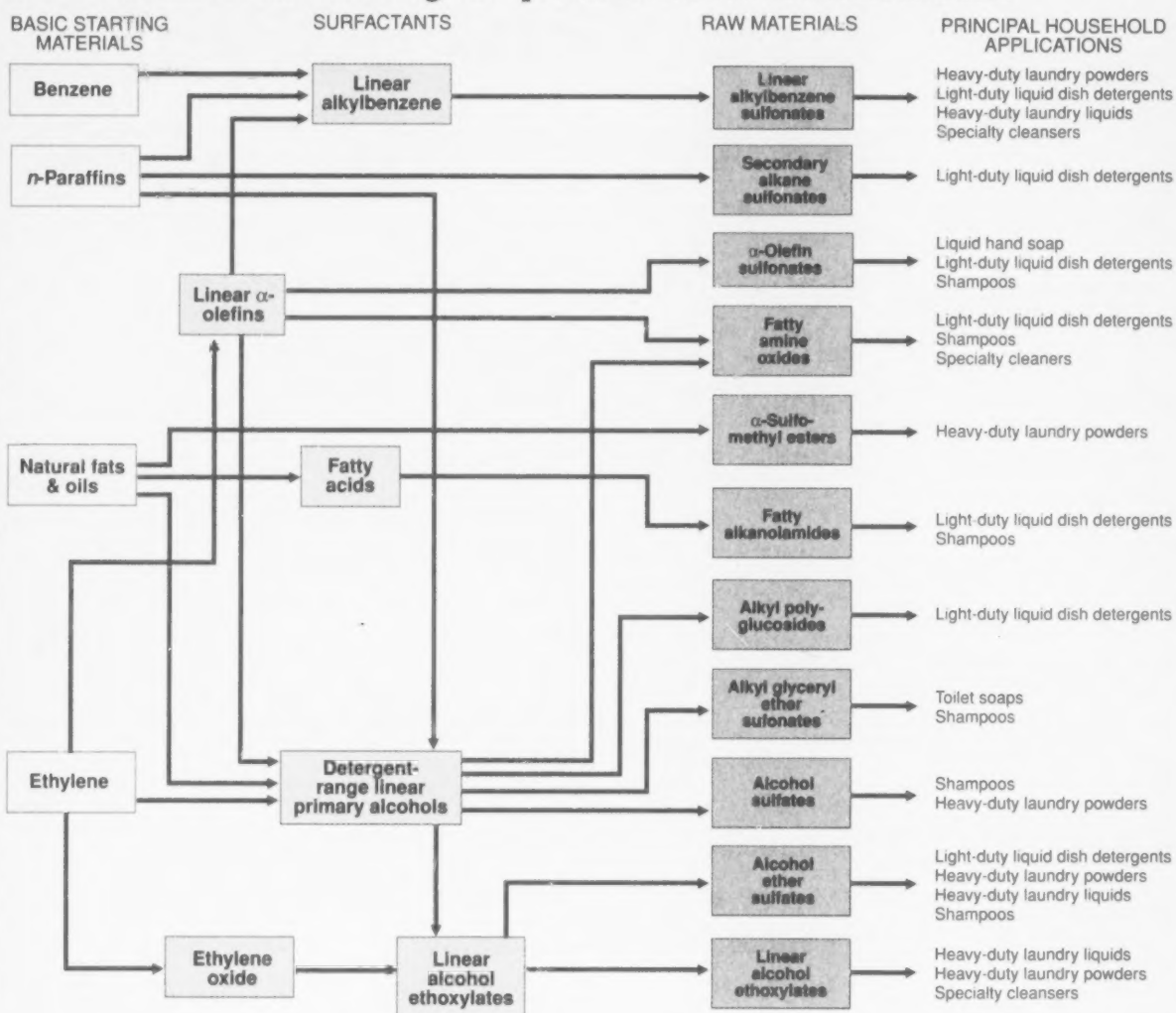
Alcohol capacity boost

Although capacity growth in petrochemical-based surfactant raw materials has been limited mostly to minor expansion projects, producers of oleochemicals have been investing in significant capacity additions, Rietkerk points out. Indeed, the industry is producing more oleochemical-based alcohols. In 1993, C₁₂ oleochemical alcohols made up roughly 50% of worldwide fatty alcohol capacity, which totaled 1.82 million metric tons, according to Joel Houston at Mamaronneck, N.Y.-based consulting firm Colin A. Houston & Associates. That's up from 1991, when oleochemical-based alcohol represented only 42% of total world fatty alcohol capacity, which then totaled 1.57 million metric tons.

By early March, Salim Oleochemicals will bring on stream a \$230 million oleochemical plant on the Indonesian island of Batam with a capacity of 60,000 metric tons of fatty alcohol per year. The expansion will boost the company's fatty alcohol production to about 100,000 metric tons per year, making it the world's third largest producer of fatty alcohol behind Germany's Henkel and Procter & Gamble, according to Salim.

Salim already operates an oleochemical plant at Belawan, near Medan on the island of Sumatra. The group also

Surfactants for household detergents—petrochemical raw materials and uses



Source: SRI International, Chemical Economics Handbook

has a pre-World War II 15,000-metric-ton-per-year fatty alcohol plant in East Germany, which it will tear down and replace with a new plant that will produce between 30,000 and 60,000 metric tons of fatty alcohols by 1997 or 1998.

As chemical producers and soap and detergent manufacturers such as Procter & Gamble add oleochemical-based fatty alcohol capacity, it encourages the industry to reformulate toward these products, cutting into the market for anionic surfactants such as linear alkylbenzene sulfonate (LAS). But even so, reformulation away from LAS hasn't happened to the degree forecast one and two years ago, says O'Brien.

As is the case in the detergent alco-

hols market, pricing of LAS relative to other surfactants plays a big part in determining its contribution to today's detergent formulations. "Today, LAS pricing is very competitive with its alcohol-based surfactant counterparts," says O'Brien. Reflecting its confidence in LAS, Vista Chemical announced earlier this month that it will invest \$100 million in a project that will reduce operating costs at its Baltimore detergent alkylate facility (C&EN, Jan. 17, page 8).

The LAS market has rebounded from negative laboratory tests showing that it, like other sulfonates, did not biodegrade as readily as many other surfactants. Larry Britton, senior research group leader at Vista Chemical, a producer of

LAS, questions the ability of laboratory testing methods by themselves to accurately predict the fate of a given chemical in a given environmental setting.

"The anaerobic test methods that regulatory guidelines routinely call for fail to take into account conditions present in nature that allow for biodegradation despite lack of oxygen," comments Britton. Anaerobic biodegradability tests are used to predict whether chemical compounds are likely to remain intact and build up over time in environments that lack oxygen—such as swamps, water-saturated soils, peat bogs, or sediments from lake or river bottoms—potentially reaching levels harmful to organisms in these ecosys-

PRODUCT REPORT

tems. "It is possible that certain substances known to require molecular oxygen to biodegrade will show no degradation in anaerobic digestors and laboratory tests, yet will biodegrade in natural environments that are typically labeled as anaerobic," Britton adds.

Using LAS (which requires oxygen to degrade) as a test substance, and monitoring carbon dioxide production in river sediment designed to be anaerobic, Britton and his colleagues were able to confirm biodegradation of LAS in the sediment. Laboratory tests, he says, fail to account for oxygen flux that occurs in natural anaerobic environments, which are seldom completely free of oxygen.

Despite these findings, competitors are busy developing products that can stand in for LAS while boasting a more positive biodegradability profile. "We are really trying to capitalize on [the trend toward more biodegradable surfactants] by doing more testing to demonstrate the biodegradability of our existing products," says Lonza's Huisking. "In what is probably the primary focus of our research and development effort right now, we are trying to build molecules that are more biodegradable for certain applications."

Indeed, a number of newer surfactants are taking some market share from LAS in selected market segments in some world regions, according to a report on LAS issued in early 1993 by SRI International. These include *n*-paraffin sulfonates, α -sulfomethyl esters of detergent alcohols, and alkyl polyglycosides. "These surfactants are often promoted as having faster biodegradability or, in the case of the methyl esters and alkyl polyglycosides, for being based on natural raw materials," the SRI report adds.

To capitalize on this trend, just over a year ago Henkel Corp.'s Ambler, Pa.-based CD Division launched its family of Glucopon surfactants that are composed of alkyl polyglycosides. These compounds are made from natural raw materials—glucose derived from corn and fatty alcohols made from coconut and palm kernel oils. Then earlier this month, Henkel expanded that line with the introduction of several types of Glucopon surfactant concentrates, which are composites of Henkel's Glucopon surfactants and conventional surfactants. The concentrates can be used in the household and

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Continued from page 41

industrial and institutional markets in liquid dish and liquid hand soaps, concentrated laundry liquids, and for cleaning hard surfaces.

"Our Glucopon surfactant concentrates respond to the needs of the marketplace," says Anthony J. DeRosa, vice president of Henkel's detergent and personal care divisions. "Right now, consumers want more value for their money, along with mildness, without sacrificing cleaning performance, and they favor products made from natural raw materials. Manufacturers are committed to meeting consumer requirements, and they are under price competition and must reduce total costs."

The products also deliver the "unusual combination of detergency and mildness. They also exhibit good foaming, ease of dilution, and they do not gel," DeRosa says. The concentrates are highly active, with active ingredients making up as much as 50% of the formulation. DeRosa adds that the concentrates offer good total value, and manufacturers can obtain superior performance at lower surfactant levels than are typical with conventional surfactants.

Builder systems

Indeed, detergent formulations continue to evolve not just through changes in the surfactants mix, but also through changes in the choice of builders. Demand for builders in all detergent and cleaning end uses is expected to increase nearly 3% per year until 1996, according to the Freedonia report. Nonphosphate builders such as zeolites (which are commonly used in powder detergents) and sodium citrates (used in the growing liquid laundry detergent segment) will achieve above-average growth, according to the report.

However, owing to environmental concerns, phosphate builders will face continuing declines. Phosphates are popular builders because of their effectiveness, reasonable cost, and safety for use with appliances, fabrics, and humans. They are nontoxic to aquatic life as well. The problem is that in combination with other nutrients such as carbon, nitrogen, and potassium, phosphates nourish algae and plant growth in lakes and streams. Lack of oxygen for fish is one of the consequences of this eutrophication of water.

For now, phosphate builders have not

Detergent chemicals use will continue to grow

Millions of lb	1991	1996	% annual growth (1991-96)
Builders	3,905	4,510	2.9%
Surfactants	1,615	1,790	2.1
Bleaches	45	65	7.6
Enzymes	12	20	10.8
Other	223	265	3.3
TOTAL	5,800	6,650	2.8%

Source: Freedonia Group

been regulated out of household dishwashing applications nor out of dishwashing and laundry products for the industrial and institutional market. The regulatory picture is a little bleaker for phosphate-based household laundry products. Because most states have banned phosphate use in laundry products, nearly all manufacturers have removed it from their formulations.

As discouraging as this decline in a major outlet for phosphates has been, FMC's Furman says, the company "continues to view its phosphorus operations as a core business." Total 1993 North American demand for sodium tripolyphosphate (STPP) in consumer cleaning compounds reached approximately 690 million lb, according to FMC. An additional 280 million lb is used in industrial applications, and about 80 million lb is exported. Projected total 1993 worldwide STPP production and consumption is about 2.5 million metric tons.

"To ensure that FMC continues as the low-cost producer of STPP and is globally competitive," says Furman, "the company is making changes in its phosphorus operations to reduce costs and maintain our cost advantage."

Although U.S. laundry detergent manufacturers have been forced to remove phosphates from their products, it has not been easy to find a replacement chemical that works as well. "The ideal builder system remains elusive, [because] science has not yet found the perfect balance between biodegradability, hydrolytic stability, sequestration capability, and cost," says Grime of Procter & Gamble.

Carbonate and silicate systems supported by polyacrylate dispersants now have a predominant role as builders in today's laundry detergent formu-

lations. "Citrate has reappeared in some products to support building, dispersion, and solubility. However, its cost and limited sequestration ability have confined it to a supporting role" in the laundry detergent marketplace, Grime adds.

Zeolites dominate builders

More than any other builder, zeolites have emerged as the preferred phosphate substitute. Their ability to remove calcium ions from the wash water solution is well known. However, as detergent R&D organizations around the globe focus their formulation efforts on zeolites, they are taking advantage of zeolites' other beneficial functions, says PQ's Gudowicz. Zeolites are effective in removing manganese and iron ions that can stain fabrics. They are less effective in removing magnesium ions, but, when coupled with silicates, they present a very cost-effective package, he says.

In the recent move to higher density concentrated detergents, the ability of zeolites to adsorb liquid nonionic surfactants to keep the product lump-free and free-flowing plays an important role in the manufacturer's production and particle formation scheme. Another benefit is that the high adsorptive surface area of zeolites can trap dispersed particles and keep them from redepositing on the fabric. Finally, zeolites are safe to both humans and the environment, Gudowicz adds.

Besides acting as a detergent builder, zeolites function as a particle formation process aid, which is important as deter-

gent manufacturers move away from classical spray-drying to alternative forms of particle-making in an effort to produce denser powder concentrates. This secondary role of zeolites "will guarantee the use of these materials for years to come," says Grime.

Anhydrous zeolite demand in the U.S. has grown from about 50,000 metric tons in 1985 to 300,000 metric tons in 1993, according to PQ. Gudowicz foresees modest growth that could boost consumption to 400,000 metric tons (450,000 metric tons on a hydrate basis) per year by the end of the decade.

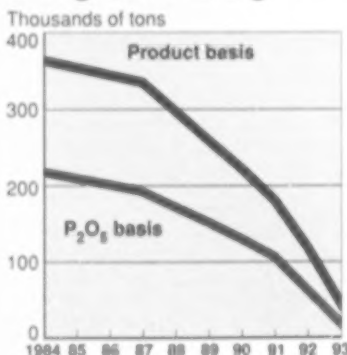
Ethyl Corp., another producer of zeolites, says growth has leveled off to about 5 to 7% per year following the explosive growth of the past few years when legislation banning use of phosphates in laundry detergents sparked a massive reformulation effort by the major manufacturers. "There is still some switching over to zeolites by manufacturers of local brands in areas where phosphate use has not been banned," says John McChesney, a marketing communications manager at Ethyl in Baton Rouge, La.

Citing growth in this market, PQ has been rapidly expanding its zeolite capacity over the past couple of years. In 1993, it brought on capacity at new plants in Bangkok, Thailand, and Seoul, South Korea, making PQ "the largest zeolite producer in the world," says Gudowicz. Asia, he notes "is a real growth market for zeolite-built detergents."

Although zeolites are the preferred stand-in for phosphates in household laundry detergents, they cannot be used as a one-to-one replacement for phosphates. "You can't yank out phosphate from a detergent formula, throw in zeolite, and expect to be home free," says David T. Hermann, a marketing manager for PQ's industrial chemicals division. "This was the lesson the industry learned in the early 1980s." Since then, the industry has reformulated, using new surfactant systems and cobuilders (such as silicates and polymers) so that the final formulations now perform as well as the old phosphate formulations, he notes.

Another challenge zeolites present is that they are insoluble crystals. Therefore, they can only be included in liquid detergents if special attention is given to the prevention of particle settling through the structured liquid technology, which basically prevents

Use of phosphates in home detergents is falling in U.S.



Source: SRI International, Chemical Economics Handbook

phase separation, says Gudowicz. In the past, zeolites have been avoided in liquid systems, he says, and an alternative builder such as sodium citrate has been used or the formulation contained no builder at all. "However, we are now seeing zeolite-built liquid laundry detergents being marketed in the U.K., Italy, and Australia."

Sodium silicate plays an important role in the success of zeolite-based concentrated laundry powders. It acts as a binder (that aids in forming a dust-free granule), an anticorrosion agent, an alkali (to aid in soil removal), and a minor builder—mainly for magnesium sequestration. Today's premium formulations contain only 3 to 5% silicate to 35% zeolite. This is a sharp reduction from older high-phosphate formulations that contained more than 10% silicates. "While the change was good for the company's zeolite business," Hermann adds, "we lost half of our silicate market [share] overnight when the market went concentrated and [when it] pulled phosphate out."

Dishwashing products

While demand for zeolites levels out in the laundry products segment, zeolite producers are watching for opportunities in the automatic dishwashing segment. Hermann says FQ is doing some research into automatic dishwashing products that are based on powdered silicates and zeolites. Although changes in nonphosphate legislation may be needed to stimulate widespread reformulation, the industry is watching with interest to see if the several minor non-phosphate automatic dishwashing products introduced in 1992 will be successful in the market.

Some manufacturers have developed improved formulation technology to produce phosphate-free automatic dishwashing products, but manufacturers in countries where phosphate is not a concern prefer phosphate-based detergents for their proven performance, says Peter P. Carfagno, detergent products technology manager for phosphates at FMC's Chemical R&D Center in Princeton. "When European nonphosphate prod-



Technician measures bulk density of persalt sample.

ucts are tested in the U.S., we are told they do not satisfy the performance needs of most U.S. customers," he adds. This is due, among other things, to differences in U.S. machine design and use of water softeners in Europe, he explains.

In the U.S., too, compact, phosphate-built automatic dishwashing products have been gaining momentum in the marketplace. While only one such product was introduced in 1992, several appeared over the course of 1993, and more are expected to be launched this year, says Carfagno.

To capitalize on this trend, FMC has developed special grades of phosphates tailored to the needs of formulators of detergents for compact automatic dishwashers. For example, FMC is supplying specialized tripolyphosphate products that provide the appropriate solubility and dispersability required for automatic dishwashing formulations, says Carfagno. "As ultra automatic dishwashing products become more dense, producers find they must work on the solubility of their formulations. Not only must they look at the weight-volume efficiencies of the ingredients, but they must also focus on the formulation's dissolving characteristics. Formulations are developed and processes are designed to ensure good solubility within the low dose requirements of the compact format."

Phosphate-based dishwashing formulations are preferred not only in the

household dishwashing market, but in the industrial and institutional segment as well. In fact, demand for phosphate-based industrial and institutional formulations is growing because of the trend toward collecting statistical information that helps match specialized product forms to specific cleaning needs, says Carfagno.

New data systems can monitor the dispensing of the detergent and tailor its dosage to the cleaning demands of the washing situation at hand, which may change by the time of the day and type of meal being served. Fine-tuning the product results in the more efficient use of chemicals for end users, he notes. Dispensable product

forms such as blocks and slurries are integral to this type of cleaning, and phosphates are often key ingredients in producing these special dispensable detergent forms.

"Industrial and institutional products are formulated with phosphates because when the formulator and end user need assurance of good hygiene and that surfaces are sanitized, no one can challenge the job that phosphate does in removing soil and enhancing overall cleaning," says Carfagno. "Good cleaning is an essential first step needed to ensure good sanitizing. So, we see a good outlook for phosphate in both food plant and restaurant cleaning applications."

Detergents with bleach

To be sure, household consumers, like those in the industrial and institutional market, are concerned with getting good cleaning power from the products they buy. In the laundry segment, formulators have been working to develop products that clean clothes effectively even while the temperature of wash and rinse water used in energy-conscious U.S. households drops. One way to solve this dilemma has been to add nonchlorine bleach to detergent formulations.

It's not surprising, therefore, that detergent-with-bleach laundry products have led the multifunctional detergent trend. During 1993, almost all detergent makers, including private label formula-



Marine cleaning solutions contain sodium percarbonate.

Solvay Interlox photo

Wardell reports. The U.S. recession, which has moderated wash load volume growth to some extent, has had a depressing effect on overall detergent pricing. That, in turn, has exerted downward pressure on ingredient suppliers.

Another blow to the perborate market is possible competition for market share by percarbonates. "In the detergent-with-bleach product segment, we see potential interest in the use of percarbonate in place of perborate," says Merluzzi, although sodium

percarbonate is now mainly used as a bleach booster in all-fabric bleaches. Sodium percarbonate has traditionally not been able to compete in this market because it is less stable than perborate.

However, Merluzzi says, "FMC has developed technology for a stable per-

carbonate to respond to the industry's needs." Degussa, too, says it has "successfully obtained coated percarbonates that have storage stabilities in detergent formulations comparable to perborates," according to Wardell. "And we are currently working to improve percarbonate bulk handling characteristics."

Although peroxygen chemicals effectively boost detergent cleaning power, they are limited in that they require moderate wash temperatures of at least 60 °C to achieve reasonable bleaching rates. Recognizing this, companies are "looking at new low-temperature bleaching systems for the long-term future," says Solvay Interlox's Parker. "There is no doubt that, with the changes envisaged in wash temperature, machine design, and energy conservation, the search for even lower temperature performing products will increase," he says.

Some R&D efforts are focused at designing bleach activators that transform peroxide into organic peracids, which oxidize and decolorize stained matter,

tors, have developed a detergent-with-bleach concentrated product, observes Richard A. Merluzzi, FMC's business director of peroxygen specialty products.

These liquid and powder products have gone from holding 3.5% of the total household laundry market in 1986 to capture a 10.9% share in 1993, according to Procter & Gamble's Grime. In Canada, the penetration of detergent-with-bleach products stands at about 9%; in Latin America, these products have expanded quickly to capture roughly 10% of the market since their introduction there in 1992.

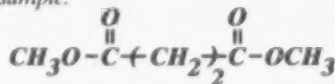
Perborates—solid carriers of active oxygen that form hydrogen peroxide in solution—are the predominant bleaching component in household detergents today. Among perborate forms, in the U.S. perborate tetrahydrate has been displaced by perborate monohydrate, which is more soluble under the relatively cool U.S. laundry wash water conditions.

In North America, perborate growth is expected to continue at over 5% per year as additional detergent brands are formulated with perborate bleach and as existing brands gain increased consumer acceptance, according to Richard Wardell, industry manager of the peroxygen chemicals division at Ridgefield Park, N.J.-based Degussa Corp. In early 1993, responding to growth in this market segment, Degussa brought on stream a new plant in Antwerp, Belgium, to produce sodium perborate monohydrate to serve worldwide demand.

Although growth in demand for perborate monohydrate has been strong, perborate pricing has been relatively weak,

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imparting a brightening effect. Degussa, for one, is working on low-temperature bleach activators based on renewable raw materials.

Enzyme use increasing

The proliferation of peroxygen-based bleach additives in detergents has improved the market for detergent enzymes. The use of enzymes in laundry products had been limited because enzymes become deactivated by chlorine bleach. Detergents with perborate bleach, with which enzymes are compatible, have allowed consumers to bypass chlorine bleaches. Solving this problem has been one of the factors that has encouraged a steady increase in the use of enzymes in detergents.

"The detergent enzyme segment of our business continued to expand in 1993," observes Thomas Meygaard, a product manager at Elkhart, Ind.-based Solvay Enzymes, which produces alkaline proteases for use in laundry detergents and a protease amylase combination product for use in detergent or automatic dishwasher applications.

Indeed, because enzymes are compatible with a number of trends in the detergents market, their growth in the future is ensured. In fact, "many products were reformulated in 1993, generally increasing the volume and types of enzymes used," Meygaard adds. For example, Procter & Gamble's Grime notes, "by the nature of their catalytic chemistry, enzymes provide the space-efficient performance that compact detergents require."

"The green movement likely will continue to be a significant factor in this industry, which is good for our business," adds Meygaard. "Enzymes are natural, biodegradable proteins produced through fermentation. They are very compatible with a green movement."

Another trend—consumer demand for multifunctional detergents—will also drive enzyme growth in the detergents market. For example, genetically engineered enzymes are being used increasingly in laundry products to improve color fastness, says Roland W. Kohl of Hampshire Chemical, Lexington, Mass. He adds that Hampshire—a producer of a nitrilotriacetic acid trisodium salt used as a detergent builder and of specialty surfactants—is also developing proprietary substances that would work in concert with enzymes to address the color-fastness problem.

As ingredient suppliers work to de-

velop new types of enzymes, bleaches, and other additives that perform better in powder concentrates and the newer and fast-growing liquid detergent products, ICI Surfactants is attacking the market from another angle. The company is promoting its Aquaperle concentrated nonaqueous liquid laundry detergent formulation, which is the only liquid that can support the addition of perborate bleaches, according to Lee Richards, detergents market manager for ICI Surfactants, Wilmington, Del.

The polyethylene-glycol-based Aquaperle is four times more active than conventional powders, uses one third the chemicals, and requires 70% less packaging while providing comparable wash performance.

U.K.-based parent ICI is already producing commercial quantities of an Aquaperle formulation tailored to European wash conditions; the product was launched in Europe between 1990 and 1991. As a next step, over the past year, the company has been developing formulas for U.S. wash conditions.

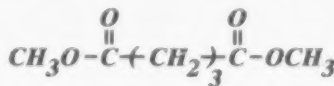
"We think we have a decent shot at putting the first commercial [Aquaperle-based] product on the market in the U.S. in 1994," says Richards. The industry's move from powder compacts to concentrated liquids that contain as little as 35% water "works right into our hands," Richards adds. Aquaperle could represent the next step in this evolution: an even more concentrated nonaqueous liquid that can be more highly loaded with additives.

Fillers and reformulation

Although ICI warmly greets the move toward compact detergents, producers of detergent fillers such as sodium sulfate are hoping that trend will lose momentum. Before environmentally minded consumers began to demand concentrated detergents in less packaging, consumers believed that "bigger was better" and the "big box" ruled the market, reminisces Bill Rigney, marketing manager for sodium sulfate for the minerals products division of Philadelphia-based Elf Atochem North America.

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The typical laundry powder was formulated with about 35% sodium sulfate filler to add bulk to the detergent and fill that box, notes Rigney. In contrast, today's concentrated detergents contain no more than 10% sodium sulfate and some products contain none. As a result, consumption of sodium sulfate by the U.S. detergent industry has dropped as much as 40% since 1992, Rigney notes.

However, sodium sulfate will not be shut out of the detergent industry entirely, he predicts. For one thing, sodium sulfate is not just used in laundry powders—it is also used in dish powders, a market in which concentrated products do not yet dominate.

And even in the laundry market, sodium sulfate still has a place, he says. Besides acting as a filler in laundry detergent formulations, sodium sulfate acts as a flow aid, dispersing active ingredients "so they don't end up in one sock," for instance, says Rigney.

"And the big box has not gone away," Rigney says. He points out that after concentrates took over the Japanese market in the late 1980s, traditional detergents later regained a significant share. In the U.S., the move to concentrates "has leveled off and we may just see traditional detergents regain some market share here." Some consumers are turned off or confused by concentrates' costing more per ounce than traditional detergents. "They are not completely convinced that they are getting more bang for their buck," he comments.

The fabric softener market has also been affected by the trend toward concentrated products. Producers of fabric softeners face the same public pressure to minimize plastic waste. Concentrated liquid fabric softener products, which in the U.S. represent 55% of the market (with tumble dryer sheets representing 45%), contain higher active ingredient levels today than they did seven years ago and are sold in packages that reduce waste, according to Uwe Sebold, a researcher with Akzo Chemicals' detergents and surfactants unit, Duren, Germany.

Environmental pressures have also forced the fabric softener industry to look for replacement materials for dihydrogenated tallow dimethyl ammonium chloride (DHTDMAC)—the classic softener active ingredient. Today, volumes of DHTDMAC used in Europe have declined by more than 70% and in the U.S. by more than 20% in recent years, says

Sebold. In Europe the primary substitutes are esterquats, which biodegrade more rapidly than does DHTDMAC and are less toxic to aquatic organisms, he observes. In North America, replacements are mainly imidazolines and amidoamine quats, allowing formulation of higher active concentrates in conjunction with DHTDMAC.

The market for soda ash has also been challenged by the environmentally conscious move to concentrates. In detergents, soda ash simultaneously functions as a builder, agglomerating agent, surfactant carrier, and an alkaline source. The trend toward compact household laundry detergents has forced the industry to focus increasingly on the granulation technology used to make these products, according to William Breunig, FMC's marketing manager for soda ash.

To keep up with detergent makers' needs in formulating and developing compact home laundry detergent powders, FMC supplies several different soda ash products of varying densities and absorptivities. The company's tech-

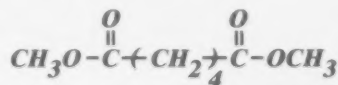
nical service department in Princeton, which has a team dedicated to the detergent industry, has been working on improving soda ash products.

Soda ash sales to the domestic detergent market were down slightly for 1993 versus 1992 because heavy-duty liquid laundry detergents gained share against powders during 1993, observed Breunig. He says that the powder-to-liquid ratio fluctuates from year to year and may have changed from 60% powder-40% liquid to 55%-45% for 1993. "The swing in powder-to-liquid detergent sales had an impact on soda ash demand," he says; "but we anticipate that 1994 will be a strong year in terms of worldwide demand for soda ash. With the continued shutdown of synthetic capacity, demand for natural soda ash from the U.S. will continue to grow."

Breunig adds that the switch to liquid laundry detergents does have an upside for FMC because it requires the use of more sodium sesquicarbonate, a buffering agent for liquid detergent systems, including laundry, automatic dishwasher-

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ing, and institutional and industrial detergents.

The overall market for U.S. soda ash in 1993 is estimated in excess of 10 million tons. Domestic consumption of soda ash is about 7 million tons, and consumption of soda ash by the cleaning compounds industry represents approximately 12% of that figure, according to FMC. Exports of soda ash are expected to exceed 3.2 million tons for 1993.

International markets

Increasingly, ingredient suppliers must think about exporting their products or producing them outside the U.S. Because the big U.S. soap and detergent producers are operating on a more global scale, they "are requiring a global supply capability," says Witco's Ackerman. With its recent Schering A.G. acquisition, she continues, "Witco is now positioned very well to provide product on a global basis. Efforts to find ways of producing exactly the same type of product with the same specifications and quality characteristics at multiple locations around the world continue."

In addition to meeting their customers' demands for more global formulations, U.S. ingredient suppliers are also looking to outside markets to help them fend off any lingering effects of the poor U.S. economy and to recoup the investments they have made in technology. "Opportunities outside the U.S. and Europe continue to be encouraging and may supplement any downturns we see in our more established markets," says Ackerman. Indeed, developing countries, such as those in South America, offer particularly good growth potential for detergent chemicals throughout the rest of this decade, say many ingredient suppliers.

For example, "improving economic conditions, including widespread privatization, increasing consumer purchasing power, and growing foreign investment make South America one of the most promising regions in the world for surfactant growth," according to Don Carswell, manager of Latin American research at Houston & Associates.

In addition to the growth in demand that goes hand-in-hand with improving standards of living, developing countries are often an outlet for ingredients such as phosphates that have fallen out of favor in the U.S. Indeed, "the outlook for phosphates in home laundry deter-

gents outside the U.S. is very good, particularly in Latin America," according to FMC's Carfagno. He notes that the home laundry detergents marketed in Latin America are typical of the conventional formulations sold for many years in the U.S.

"Phosphates continue to be used in home laundry detergents in countries such as Mexico, based on the inherent cost and performance benefits of STPP over other builder systems," says FMC's Furman. The Mexican market for phosphates in home laundry detergents is attractive to FMC because the company can efficiently transport material from its low-cost, 450 million-lb-per-year STPP plant in Green River, Wyo. The passage of the North American Free Trade Agreement, he expects, will help solidify the Green River plant as a long-term source of phosphates for this market.

Although the outlook for phosphates in Latin America is good, many ingredients that are no longer used in the U.S. are likely to be phased out of de-

veloping countries, too. Thus, opportunities abound for detergent ingredient suppliers who can position themselves to take advantage of reformulation trends that usually lag those in the U.S.

In South America, for example, surfactant markets will grow quickly—not only in volume terms owing to the improving standard of living, Carswell says. "The dollar value per unit volume will grow even more rapidly, as branched alkylbenzenes are replaced by LAB and other, more sophisticated surfactants."

LABs are expected to replace the less biodegradable branched alkylbenzenes in South America by 1995, according to Carswell. Most companies in Colombia changed to the use of LABs in 1993 and Peruvian producers are expected to change over in 1994. This will leave only minor markets in South America, such as Ecuador and Bolivia, as branched alkylbenzene consumers, he adds.

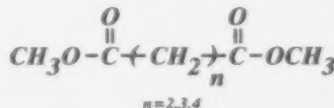
Producers of linear α -olefins, which can be used to make LABs, may also

Continued on page 58

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Continued from page 55

benefit from this trend. Demand for these raw materials is up not only in South America, but also in the Philippines and Indonesia, where detergent producers are just now converting from branched alkylbenzene-based surfactants, explains C. Eric Spore, an α -olefins product specialist at Chevron Chemical, Houston.

Environmental standards will inevitably become more consistent worldwide as the industry moves toward a global marketplace, says Douglas R. Wright, president of environmental affairs at Colgate-Palmolive, New York City. "The chemistry in detergent formulations will be scrutinized more than ever," he adds. "We [in the detergent industry] have an obligation to assure everyone, including ourselves, that our formulations are indeed environmentally compatible."

Recognizing this, the detergent industry and its suppliers have been working to gain a more sophisticated understanding of the environmental impact of their products. The Soap & Detergent

Association (SDA), which represents roughly 135 soap and detergent manufacturers and raw material suppliers, is committed to remaining "a technically driven association dedicated to research that develops accurate and reliable information about the human and environmental safety of the industry's products," according to Gerald R. Pflug, SDA's president.

As part of this movement, the industry has begun to judge the environmental friendliness of each of its ingredients not just by looking at the raw materials from which it was made, but by analyzing its entire life cycle from production to disposal, says Spore. The public has given detergent products that are based on petrochemicals a bad name. Consumers have gravitated toward products made from oleochemical feedstocks such as coconut oil.

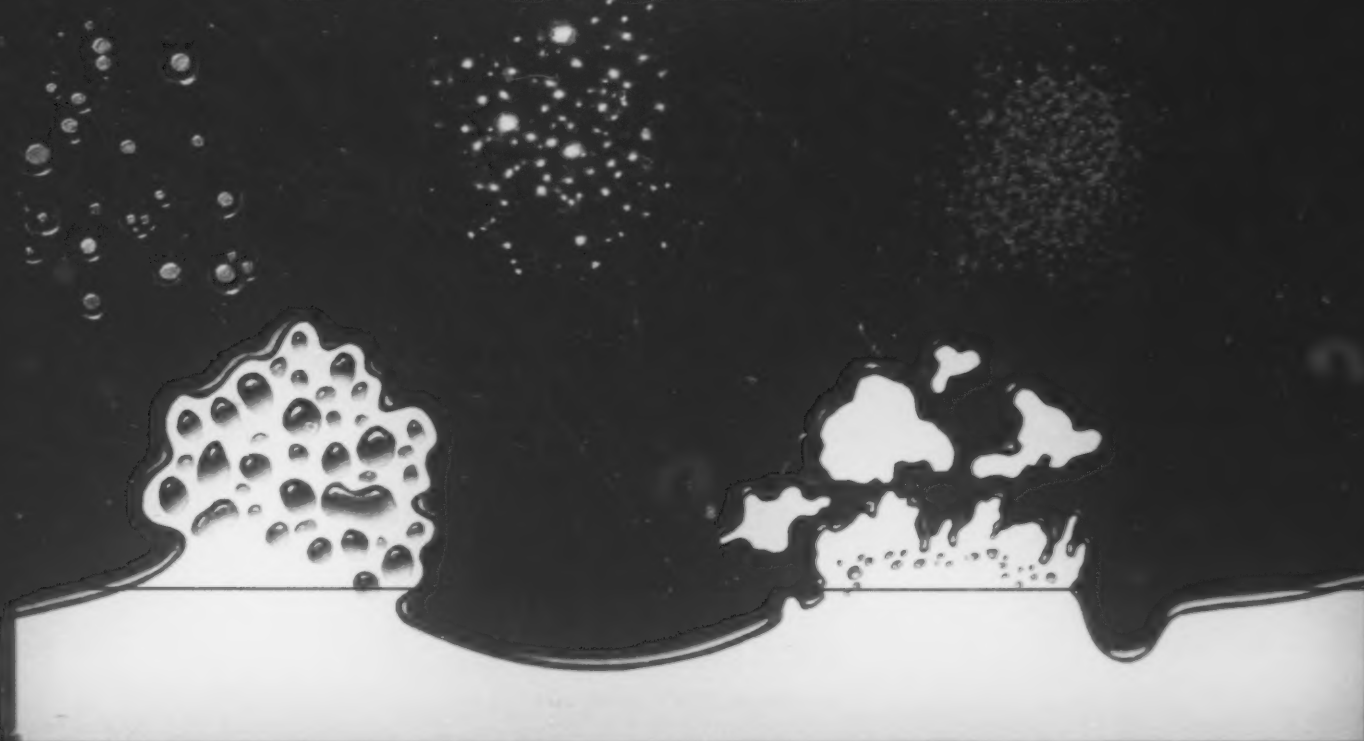
However, "looking at the entire life cycle of each type of product, you see that, from an environmental standpoint, there are advantages to petrochemical-based products," says Spore.



Solvey Interiors photo

Concentrated home laundry powders have been rising in popularity.

Problems.



Oleochemicals are derived from plants, which must be fertilized, creating runoff that may not always be good for the environment. And these chemicals must be processed the same way petrochemicals are to get a detergent ingredient, such as lauryl sulfate, for example, Spore adds.

Armed with a more sophisticated understanding of how their products affect the environment, detergent and ingredient suppliers are making a concerted effort to better educate both consumers and regulators so that future decisions might be based more on sound science rather than on emotion. Research, says Pflug, is "the cornerstone of SDA's efforts to avert or correct the unnecessary regulation of cleaning products, their ingredients, and their packaging."

For example, SDA applauds the Federal Trade Commission's (FTC) ruling in July 1992 that claims of environmental terms and labels used in marketing various soap and detergent products should always be backed by competent

and reliable evidence. Through this ruling, the FTC supported SDA members' "long-standing practice of providing useful and fact-based environmental information about its products and packaging," says Pflug.

The public, too, seems to be better informed. The environmental movement, "while it is having a tremendous impact on the soap and detergent industry as a whole, has quieted down a bit," observes Texaco Chemical's Borland. "In the future, any kind of attention to this issue will be much more rational," she predicts. "Consumers and regulators will be relying more on cold, hard statistics as they realize that this issue can't be driven by emotion."

Indeed, addressing the environmental issues surrounding soap and detergent products is just one of many challenges that raw material suppliers must face in today's marketplace. "Competitive pressures faced by the detergent industry in 1994 will create mounting demand for new raw materials that can enhance product effectiveness, satisfy a

variety of regulatory requirements, and address the economic needs of suppliers and consumers," according to Ken Schoene, director of performance chemicals for BASF, Parsippany, N.J.

"Success in the evolving market will increasingly depend on the effective utilization of multipurpose raw materials such as surfactants, polymers, and other agents capable of global application," says Schoene. "As research, development, and product distribution all become progressively more global, the need for suppliers to provide timely and innovative technical support becomes particularly important."

The industry's demands on raw material suppliers are not likely to let up soon. In order to meet future marketplace requirements, "the emphasis must be on chemistry or chemical technology," says Procter & Gamble's Grime. "The days of 20-year lifetimes for detergent chemicals are gone forever," he predicts. "Another period of dynamic change is just around the corner." □

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